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USING MODERN EQUIPMENT TO SPRAY ALL PARTS OF THE TREE

Orchard Spraying and Spray Equipment

By W. S. HOUGH

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INTRODUCTION

Spraying is an art. Skill in handling a sprayer and its equipment is acquired through intelligent practice. Efficiency accompanies skill. In the art of spraying, efficiency means that all parts of the tree are sprayed alike and thoroughly, and that the tree is sprayed in the minimum time. Much spraying has been done in the "hit and miss" fashion — hitting the lower part of the tree and missing most of the upper part. *Uniformity of application of the spray material on all parts of the tree is the crying need in too many orchards.*

This publication is an attempt to give the practical results of an investigation of spraying and spray equipment extending over the past four years at Winchester.* Various nozzles and equipment were used in practical orchard operations and in experimental spraying. Tests and selections were made on the principle that one ought to use spray equipment which will deliver a generous quantity of spray to all parts of the tree without washing the fruit or foliage in a stream, or without going to the opposite extreme of attempting to envelop the branches in a thin, floating fog. All measurements of volume and spray drive were made in actual spraying operations, and they are sufficiently accurate for practical purposes. The term "effective spray drive" is applied to the distance from the nozzle opening at which the spray will turn the leaves sufficiently to wet them on both sides while the nozzles are in motion as in spraying. This is an important index to the type or quality of spray produced. With sufficient volume and drive, one can deliver the spray to the inner branches without going to the tree trunk and spraying upward. Certain types of nozzles produce so much drive that injury to the fruit and foliage results.

*The study of methods of spraying and spraying equipment was made with special reference to the control of the red-banded leaf-roller and codling moth. Larvae of the former insect spend most of their lives on the under side of the leaves or on the side of the fruit protected by the foliage or twigs. For effective control, the spray must be driven to the places where the larvae live.

Codling moth larvae begin to wander about as soon as they have hatched. Careful observations on the habits of newly hatched larvae of the first brood revealed the fact that the greater part of their wandering period is spent on the under side of the leaves, and many of the larvae seemed to pick up enough poison to sicken them and render them incapable of a vigorous attack on the fruit. It requires a healthy and energetic worm to penetrate the skin of an apple.

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Others deliver a cone-like mist with an effective drive of only a few feet. The nozzles selected and described in the following pages have proved satisfactory in all respects when used with average care.

In addition to the nozzles and their arrangement, efficiency in spraying depends on the following: (1) personnel, (2) pump capacity sufficient for the requirements, (3) the condition in which the sprayer is kept, (4) selection of equipment suitable for the machine used. The relation of the last three factors to the type of spray produced is discussed in the following pages.

AMOUNT OF SPRAY PER TREE

Since trees of the same age vary greatly in size, the amount of liquid required to spray them varies accordingly. For this reason the height and spread of a tree, rather than its age, were considered in connection with measuring the amount of liquid required to spray it. Each tree was sprayed several times and different equipment was used each time. The size of each tree and the minimum amount of liquid required to spray it are shown in Table 1. In all cases, the trees received a liberal quantity of medium coarse spray, and the amount was measured. An effort was made to avoid drenching, but there was some drip from the outer branches. The foliage was wet on both sides and the upper limbs were not neglected. When an amount less than that given in Table 1 was applied, some foliage or fruit remained dry or only partially covered. Measurement of the amount of spray applied revealed a variation according to variety and type of the tree. A tree with an abundance of foliage and numerous branches required more liquid to cover it thoroughly than a tree of less density but of approximately the same size, as, for example, trees numbers 6 and 7 in Table 1. Two York trees, numbers 9 and 10, were the same age and almost the same size, according to the measurements. But the outline of number 9 was distinctly triangular, while number 10 was almost as wide at the top as at the bottom. A difference of five gallons was required for these two trees. Experience has demonstrated that as many gallons are required to

TABLE 1
AMOUNT OF LIQUID REQUIRED TO SPRAY APPLE TREES OF VARIOUS SIZES

No.	Variety	SIZE OF TREE*		Number of Gallons
		Height (feet)	Spread (feet)	
1	Delicious	6	7	.3
2	Delicious	8	8	.4
3	Stayman Winesap	10½	11	1.0
4	Stayman Winesap	11½	12	1.3
5	York Imperial	12	16	4.0
6	York Imperial	14½	18	5.5
7	Stayman Winesap	14½	18	4.5
8	York Imperial	18	23	9.0
9	York Imperial	22½	26	11.0
10	York Imperial	23½	26	16.0
11	York Imperial	25	30	20.0

*The height represents the highest level of the main body of foliage. The spread is the diameter of the tree as outlined by the main body of foliage. Protruding branches were not included in the measurements.

spray a tree thoroughly in the dormant period as in the summer applications. In the dormant spray, all of the branches must be wet on all sides, and in doing this a large amount of spray is driven into the atmosphere.

CAPACITY OF SPRAY MACHINE

The capacity of the spray pump is of first importance in considering what nozzle equipment should be used. The amount of spraying to be done and the pressure to be maintained are the most important factors to be taken into consideration when choosing a spray machine. Trees not exceeding twelve years of age can be sprayed efficiently with a pump of eight to ten gallons capacity. But an orchardist sacrifices thoroughness for speed when he attempts to spray as rapidly with a ten-gallon per minute outfit as another does with a machine of fifteen gallons capacity. Such a practice is costly. The smallest spray machine for the average bearing commercial orchard in Virginia should have a pump with a rated output of fifteen gallons per minute and an engine of six or eight horse power. In attempting to spray as many as 1,200 trees of bearing age with a smaller outfit, there is a loss of time and a corresponding increase in the cost of application. For orchards above 25 years of age, and having as many as 1,400 trees, sprayers of about 20 gallons capacity per minute are more satisfactory. If it requires more than six days to spray an orchard thoroughly, the number of spray machines is inadequate, or their capacity is too small for proper economy and efficiency in pest control.

THE ROD AND THE SPRAY GUN

In spraying the lower half of a tree, a careful operator, working on the ground, can do equally thorough work with a spray gun or a four-foot rod equipped with a three- or four-nozzle head. The spray gun should be set about three-quarters open in order to produce a spray of proper quality. Changing the type of spray from a very fine mist to a stream should not be left to the discretion of the average man who handles a gun. The outstanding advantage of a nozzle combination is that it produces a spray of proper type, regardless of what the operator is thinking about or trying to do.

The gun must be opened to throw a stream to the top of the average bearing tree. It is common experience to find the upper third of the tree imperfectly covered where guns are used. In producing a spray of proper type, the distance of effective drive of a spray gun does not exceed the drive of a four-nozzle head. Furthermore, in order to get the actual distance of effective drive of the latter, the length of the rod must be added to the distance of the drive. For example, at 300 pounds pressure, a four-nozzle head on a six-foot rod produces an effective drive of 21 feet, compared to the 15-foot drive of a double gun. The length of rod suitable for work on the tank or tower will

vary from five to ten feet, according to the average height of the trees to be sprayed. As a rule, a rod five to eight feet long is preferred. For spraying the lower half of the tree from the ground, a rod four feet long is preferable.

PRESSURE AND VOLUME

A comparison of the performance of the same nozzle equipment (Table 4) at different pressures shows the effect of pressure on volume and spray drive. Spray machines of eight to ten gallons capacity should not maintain more than 250 to 275 pounds pressure. Machines of fifteen gallons capacity will maintain 300 to 325 pounds without developing trouble. Outfits of greater capacity, equipped with fifteen horse power engines, will maintain any pressure within the limits of safety for orchard spraying. As a rule, it is not advisable to spray apples with a pressure above 400 pounds. For average conditions, 300 to 325 pounds is preferable.

If a spray machine is regularly operated at the very limit of its capacity, mechanical trouble usually develops, resulting in a decrease of quality and volume of spray. In order to maintain the production of the right quality of spray and to prolong the life of the machine, *the volume delivered each minute in spraying should be from two to five gallons less than the rated capacity of the machine.* This should be the guiding principle in selecting nozzle equipment.

SPRAY HOSE*

A certain amount of pressure is lost in the spray hose due to friction. The amount of pressure lost in 50-foot lengths of hose of different diameters is shown in Table 2. One does not observe much effect on the quality of spray delivered until the "friction loss" between the pump and the end of the hose exceeds 25 to 35 pounds. The effect of the diameter of the hose on the measurable factors in spraying is given in Table 3. It is evident that the pressure lost through friction in a three-eighths inch hose materially reduces the volume and drive of the spray delivered from standard nozzle equipment. A practical difference in the quality of spray delivered by the same equipment, on half-inch and five-eighths inch hose, does not develop until the volume exceeds six and one-half gallons per minute. If more than four gallons per minute is to be pumped through one hose, nothing smaller than a half-inch hose should be used. If more than six and a half gallons per minute is desired, a five-eighths inch hose should be used, in order to avoid appreciable reduction in the quality of spray delivered. A highly satisfactory arrangement for a

*For convenience, the terms "half-inch" and "five-eighths inch" are used for hose having an inside diameter of seven-sixteenths and nine-sixteenths of an inch, respectively. The latter diameters are the actual inside measurements of hose usually sold for "half-inch" and "five-eighths" inch hose.

TABLE 2

PRESSURE LOSS THROUGH FRICTION IN A FIFTY-FOOT HOSE*

Discharge Gallons per Minute	LOSS OF PRESSURE IN POUNDS		
	3/8 inch hose	1/2 inch hose	5/8 inch hose
2¼	5	0	0
3¾	25	5	0
5¼	65	15	5
8½	100	35	20
11	140	60	40

NOTE:—The pressure loss in the hose was about the same for pump pressures of 250, 300, and 350 lbs.
*Adapted from data furnished by the Bean Spray Pump Company, Lansing, Michigan.

TABLE 3

EFFECT OF THE SIZE OF THE HOSE, IN FIFTY-FOOT LENGTHS, ON THE VOLUME AND DRIVE OF SPRAY DELIVERED THROUGH A FOUR-NOZZLE HEAD

Pump Pressure (lbs.)	Spray Disc Opening (in.)	VOLUME PER MINUTE AND SPRAY DRIVE					
		3/8 inch hose		1/2 inch hose		5/8 inch hose	
		Gallons	Drive (ft.)	Gallons	Drive (ft.)	Gallons	Drive (ft.)
300	1/16	4 5/8	12	4 7/8	15	5	15
300	1/12	6	12	6¾	15	6 7/8	15
400	1/16	5¼	13	5½	16	5½	16
400	1/12	7 1/8	13	7 7/8	16	8 1/8	17
400	1/10	8½	11	9¾	16	10½	18

sprayer of fifteen gallons capacity, or larger, is a 50-foot length of five-eighths inch hose on the ground and a 15- or 20-foot length of half-inch hose on the tank. Within practical limits, there is no difference in the quality of spray delivered by the same equipment on a 50-foot length of the former and a 20-foot length of the latter size of hose.

NOZZLES AND NOZZLE ARRANGEMENT

A nozzle with six holes in the whirl disc (Fig. 1) produces a desirable type of spray cone, which is carried three times farther than the fan-like cone produced by the same nozzle with two holes in the whirl disc (Fig. 2). Nozzles equipped with six-hole whirl discs and placed in a line, at intervals of about three and a third to three and a half inches between the spray disc openings, produce a spray which is carried into the tree far enough to wet both sides of the leaves 12 to 15 feet from the nozzle openings. The spray is broken fine enough to avoid striking the fruit and foliage with a stream-like drive. The nozzle clusters or heads are of two types, the four-nozzle and the three-nozzle type (Fig. 3). The former measures about ten inches and the latter about seven inches from center to center of the outside nozzles. Increasing the interval between nozzles decreases the distance of the spray drive. However, some growers find use for a three-nozzle head in which the nozzles are five inches apart, making the width of the head ten inches instead of seven inches. The wider head produces a spray of less density and greater spread. The drive is decreased by two feet. As shown in Fig. 3, the heads can be made with one-fourth inch gas pipe fittings. To make a three-nozzle head ten inches wide, use

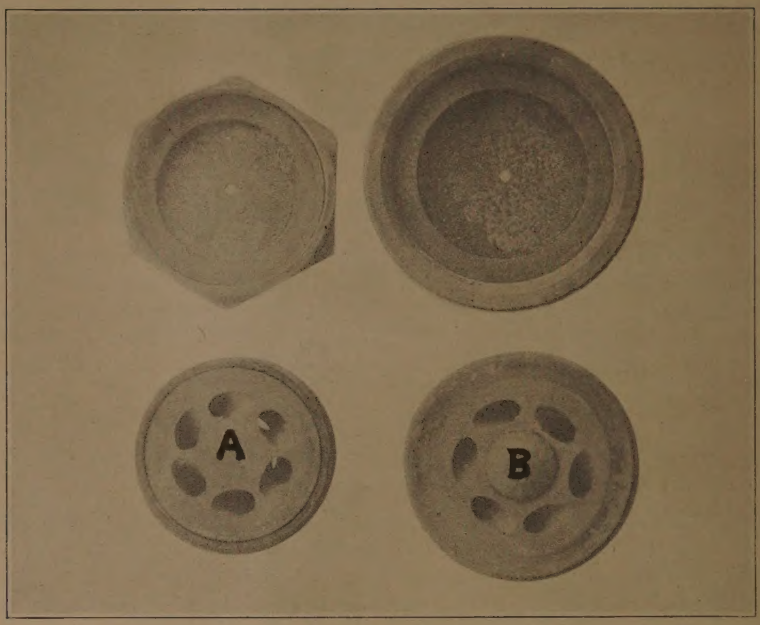

FIG. 1.—*Nozzles with six-hole whirl discs. A—Whirl disc removable from base of nozzle. B—Whirl disc and base of nozzle in one piece.*

two long (4-in.) nipples instead of the two short nipples as shown in the figure. The head is usually set at a slight angle on the end of the rod. When used on a short rod, in spraying the lower part of the tree from the ground, it is usually preferable to have the head straight rather than at a slight angle on the rod.

Spray disc openings of one-sixteenth and one-twelfth of an inch diameter have proved most useful. If a smaller opening is used, the spray is too mist-like and does not have sufficient volume or drive. If a larger opening than one-twelfth of an inch is used, there is very little allowance for wear before the disc must be discarded. The average machine will not support a sufficient number of nozzles if the disc openings are next in size above one-twelfth of an inch. Furthermore, when a disc opening wears to a diameter exceeding one-tenth of an inch, the spray becomes fan-like and the effective drive is greatly reduced.

Spray discs with one-sixteenth and one-twelfth inch openings wore to one-twelfth and one-tenth inch holes, respectively, in about 45 hours of continuous spraying. In this test, lead arsenate was used at the rate of 3 pounds in 100 gallons of water. A pressure of 300 pounds was maintained. At this

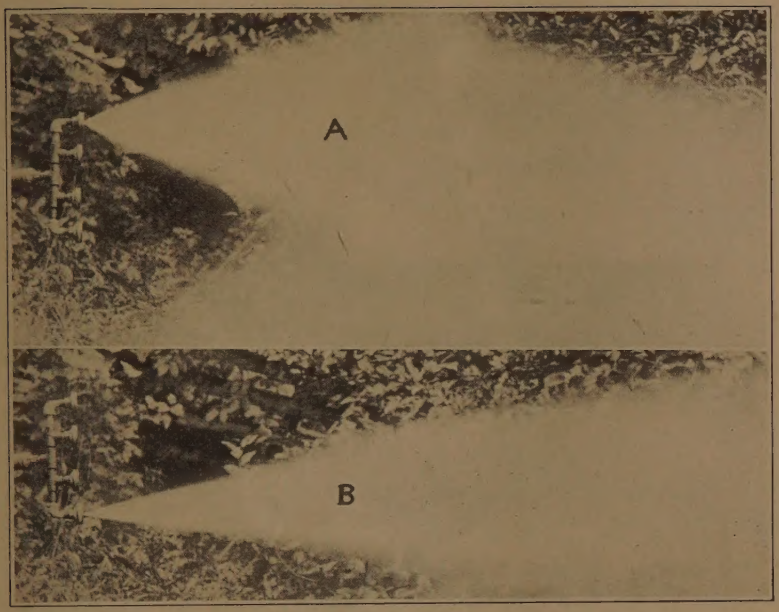

FIG. 2.—*Types of spray produced by a nozzle with (A) two-hole whirl disc, (B) six-hole whirl disc. The former spray cone wets both sides of leaves 3¼ feet and the latter 10 feet from the nozzle.*

rate of erosion, the spray discs of the size recommended should wear at least a full week before equalling the next greater in size.

SELECTING SPRAY EQUIPMENT

The capacity of the sprayer must first be taken into consideration in selecting nozzle equipment. It is also important to remember that certain equipment can be used at a pressure of 250 pounds on the smaller machines, but not with satisfactory results at higher pressures. In this connection, attention is called to the undesirability of maintaining a pressure exceeding 250 to 275 pounds in a machine of ten gallons capacity, and 300 to 325 pounds in a machine of fifteen gallons capacity. *In order to allow ample reserve, the volume delivered by the equipment used should be from two to five gallons less than the rated capacity of the pump.* The distance of effective drive is very important. If the spray does not have sufficient body and carriage to turn the leaves and wet both sides of the foliage at least ten feet from the nozzles, the value of the equipment is very doubtful. To serve as a guide in the selection of spray equipment, there is given in Table 4 the measured performance of certain equipment. The measurements were obtained in actual spraying operations. In Table

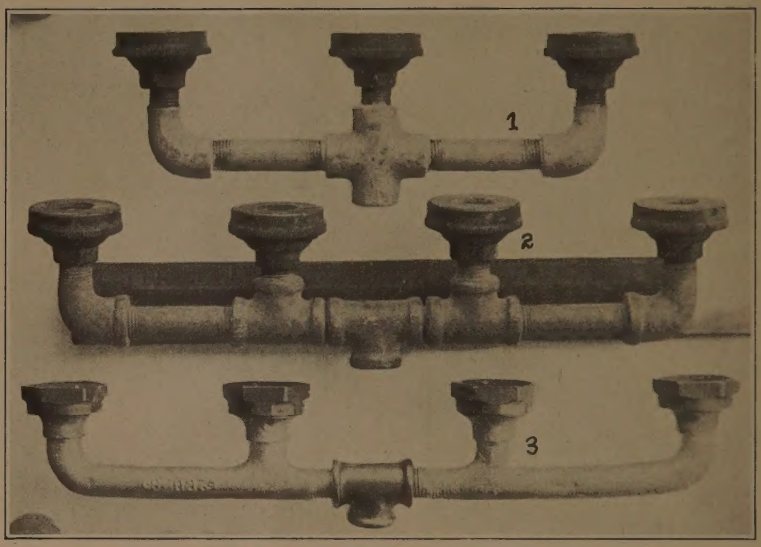

FIG. 3.—*Types of nozzle heads with nozzles. Nos. 1 and 2 are made out of quarter-inch pipe fittings. No. 3 is cast out of duraluminum. The four-nozzle heads can be adjusted to any angle on the rod. The three-nozzle head may be used straight on the end of the rod, or set at an angle by using an elbow.*

5* selections are given for machines of various sizes. All of the selections listed have been used in practical orchard spraying.

A study of Table 4 shows that not all of the possible combinations of equipment have been listed in Table 5. In considering other combinations, it is well to remember that certain factors must be taken into account which cannot be put on paper. For example, referring to Table 4, it is seen that two nozzle heads of three nozzles each will deliver seven gallons at 250 pounds pressure, when one-sixteenth inch discs are used; but when the holes in the discs wear to one-twelfth of an inch, nine gallons will be delivered. The latter volume usually exceeds the practical capacity of a ten-gollon per minute machine. The one-sixteenth inch discs must be renewed frequently to avoid this. Furthermore, if the pressure is allowed to exceed 250 pounds, the limit of practical capacity will be reached before the discs have worn to any noticeable extent. If all precautions are carefully observed, the two nozzle heads of three nozzles each can be used on a machine of ten gallons capacity. However, in practice, the necessity of observing several precautions is usually a source of disappointment and general dissatisfaction.

*In certain instances the total volume of spray delivered by combinations of equipment (Table 5) exceeded the sum of the volumes delivered by the individual sets of equipment as listed in Table 4. This was due to the fact that amounts smaller than one-eighth of a gallon were not considered in measuring volume.

TABLE 4

MEASUREMENT OF TYPES OF SPRAY PRODUCED BY VARIOUS EQUIPMENT WHEN OPERATED AT PUMP PRESSURES OF 250, 300, AND 400 POUNDS

NOTE:—Except as noted, 50-foot lengths of half-inch hose were used.

Equipment	Spray Disc Opening (inch)	Pressure—250 lbs.		Pressure—300 lbs.		Pressure—400 lbs.	
		Volume per Minute (Gallons)	Spray Drive (feet)	Volume per Minute (gallons)	Spray Drive (feet)	Volume per Minute (gallons)	Spray Drive (feet)
1. Four nozzles	1/16	4½	12	4 7/8	15	5½	16
2. Four nozzles	1/12	6¼	12	6¾	15	8 1/8*	17
3. Four nozzles	1/10	----	--	8½	15	10½*	18
4. Four nozzles	1/8	----	--	13 1/8*	?	----	--
5. Three nozzles	1/16	3½	10	3 5/8	13	4 1/8	13
6. Three nozzles	1/12	4½	10	5	13	6	13
7. Three nozzles	1/10	----	--	6 3/8	13	7¾*	14
8. Three nozzles	1/8	----	--	9½	?	----	--
9. Double gun	1/12	4 1/8	11	4½	13	5 3/8	15
10. Double gun	1/10	5¾	11	6 3/8*	15	7 3/8*	17
11. Double gun	1/8	8	11	9 1/8	15	10 1/8*	17
12. Single gun	1/12	2 1/8	9	2¼	10	2 7/8	12
13. Single gun	1/10	3	9	3 3/8	11	3 7/8	12
14. Single gun	1/8	5¼	12	5¾	13	6¼	13

* Five-eighths inch hose, 50-foot length.

? Spray coarse and lifeless, drive very weak.

TABLE 5.—EQUIPMENT FOR SPRAYERS OF VARIOUS CAPACITIES

	Spray disc opening (inch)	Volume in gallons per minute at pressure indicated		
		250 lbs.	300 lbs.	400 lbs.
I. Sprayer of 9-10 gal. capacity, 4 or 5 horse power One of the following:				
1. One rod, 4 nozzles	1/16	4½	*	*
2. One rod, 4 nozzles	1/12	6¼		
3. One double gun**	1/10	5¾		
4. Two single guns**	1/10	6		
II. Sprayer of 15 gal. capacity, 6 horse power One of the following combinations:				
1. Seven nozzles One rod on tank, 4 nozzles One rod on ground, 3 nozzles	1/16	8	8½	*
2. Seven nozzles One rod on tank, 4 nozzles One rod on ground, 3 nozzles	1/12	10 7/8	11¾	
3. Four nozzles and double gun One rod on tank, 4 nozzles Double gun on ground	1/16 1/12	8 5/8	9½	
4. Four nozzles and double gun One rod on tank, 4 nozzles Double gun on ground	1/12 1/12	10½	11¼	
III. Sprayer of 20 gal. capacity, 15 horse power One of the following combinations:				
1. Same as for 15 gal. capacity		8	8½	9 5/8
2. Same as for 15 gal. capacity		10 7/8	11¾	14¼
3. Same as for 15 gal. capacity		8 5/8	9½	10 7/8
4. Same as for 15 gal. capacity		10½	11¼	13½
5. Eight nozzles Two rods, 4 nozzles each	1/16	9	9¾	11
6. Eight nozzles Two rods, 4 nozzles each	1/12	12 5/8	13½	16¼
7. Four nozzles and double gun One rod on tank, 4 nozzles Double gun on ground	1/12 1/10	12	13 1/8	15½

*Pressure of this amount not advisable on machine of this capacity. See Table 4 for volume delivered at this pressure.

**Guns not generally recommended. See discussion of rod and spray gun.